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Fresh water distribution problematic in Nouakchott

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Abstract

Because of its geographical location, Mauritania is characterized by an arid climate. The water resources are thus limited. The annual average rainfall calculated by M. Yeslem [1] over a 60-years period (1931-1991) is 112 mm.

Nouakchott, the Mauritanian capital, knew an exceptional growth of the population, carrying it to more than 700 000 inhabitants in the year 2005 [2]. These brisk demographic trends generated a fast expansion of occupied space and a strong pressure on the social equipments and basic infrastructures and in particular for drinking water. Balloffet E.[3] and Seureca A.[4] indicate that the needs of the population of Nouakchott for drinking water, supplied from underground lake of Idini, increased exponentially the last years, in spite of the fragility of the system for which overexploitation could be prejudicial with the resources. This situation was accentuated by the lack of planning and of a framework of urban regulation. In these particular circumstances, the inhabitants of the town of Nouakchott suffer from all problems related to Water resource availability and quality.

This study, carried out over a representative sample of Nouakchott's population coming from two poor districts and a rich one, shows that the rate of access to distribution network, to the sanitation network and accessibility to water are very low for the two poor districts of El Mina and Sebkha. 22%, 4% and 35% of the population had access to the above networks. These medium rates, are due to households in the district of Tévragh-Zeina (a rich area). In addition, this work shows that the vulnerability of the distributed water is big because of the non generalization of the supplying network. In fact, the results of our physico-chemical and bacteriological analyses/tests carried out on site, in different points of the distribution channel, show that the physico-chemical characteristics of the water conform to the World Health Organization (WHO)'s norms. However, the terminal fountains were found to be contaminated with total and fecal coliforms.

This work, based on laboratory diagnosis and analyses results, can be an important prerequisite for the installation of an environment and public health management system associated with the quality of the distributed water in Nouakchott.

Keywords: Terminal fountains (TF); physico-chemical characteristics; total coliforms; fecal coliforms; aftout essahili.

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1. Introduction

The climate of the study area is generally hot and dry during most of the year. Nouakchott's climate is desert-oceanic namely Sahelian Atlantic. In fact, the raining season starts usually at the end of June. It reaches its peak in August and ends in September. The proximity of the sea attenuates the Saharian character of its climate. The overall quantity of annual rainfall remains weak according to M. Yeslem [1] and varies considerably from one year to another. The low rainfall and the high evaporation due to high temperature have turned Nouakchott to an arid zone (dry and hot).

Consecutive decades of drought in this city increase the scarceness of water resources thus becoming a severe problem. The rural exodus, due to the drought, worsened by accelerated urbanization, accentuates the already big water needs of the country's capital.

In fact, according to the data of the ONS (the National Office for Statistics) [2], Nouakchott has known an exceptional growth, carrying its capital's population from few families in 1960 to more than 700 000 inhabitants in the year 2005. This demographic evolution has generated a speedy expansion of the city and a strong pressure on the existing social equipments. This situation has also caused the development, around the urban center of the city, of slums or shantytowns areas, in precarious conditions and without the sufficient basic infrastructures especially in the field of water.

The objective of this investigation (survey) is to give some ideas about the fundamental water problems related to the environment and health quality of water distribution in the city of Nouakchott. This thought is part of an action aiming at setting a quality system which shall enables the gradual improving of water management and quality inside this city during the global cycle of resource lifespan, that is its extraction, its distribution, its use and the advent of waste liquid.

First, we shall tackle the particular context related to the availability of water resource in the city of Nouakchott situated in an arid zone and having a low rainfall and a high evaporation rate.

Second, a discussion will be made on the quality of distributed water which is closely linked to the informal mode of the resource distribution, according to the results of the physico-chemical and bacteriologic analyses (tests) that have been recently carried out in the city, as well as on an administrative investigation /survey carried out at the level of households within two model districts/areas of the city. Then, the mode of sanitation and the water-related diseases observed in the city will be described.

Finally, conclusions will be made, proposing actions and methods for improving the management and health quality of water distribution in this city.

2. Materials and methods

2.1 Quality of the distributed fresh water

The objectives of the investigations carried out on the residents are focused on the following indicators: quality of supplied water, quality of the services provided by the supplying operator, availability of water, cost of water per liter, and the problems arisen on public health (frequent diseases linked to water, death rate in the household or in the area/district).

Two investigations have taken place at two different periods and in three areas of Nouakchott; the first has been carried out in 2005 in the poor area of El Mina as well as in the rich district of Tévragh-Zeina; while the second investigation was carried out in 2007 in the two poor areas of Sebkha and El Mina.

The number of households covered by these two campaigns was 215 (of which 9 non-responding) of which 75 % live in the two poor districts of El Mina and Sebkha.

Six criteria are included in the questionnaire used for the purposes of the investigation: typology of households (standard of living), degree of sensitization/awareness of households about the quality of drinking water and environment, level of accessibility to water and sanitation, purchase price for 1m³ of water, pollution of water, diseases linked to water and to sanitation, and households' priorities.

The investigations/surveys were done face to face with the householders; the processing of the data collected was made using the statistic software SPHINX.

2.2 Experimental methods

2.2.1 Cartography of terminal fountains (TF) in Nouakchott

The cartography of the terminal fountains (TF) and storing reservoirs (SR) concerns only the districts of Sebkha and Elmina because there are no terminal fountains in Tevragh Zeina. This cartography is made using a quotation based on the status of visual quality criteria of thirty terminal fountains and water basins. These 30 TF have been chosen on the basis of geographic, environmental and health representative criteria in the two moughataas (districts) of El Mina and Sebkha characterized mainly by a poor population.

The visual quotation includes three fundamental axes: the protection area of the terminal fountain, the technical conditions/status of the TF or SR, and the health security around the TF or SR.

All these axes are distributed on 25 criteria, presented below. They are graded on 50 points. The grade (mark) of each criterion varies between 0 and 2 according to the status (0 applies to bad status, 1 applies to medium status, 2 applies to good status).

The 7 criteria related to the 1st axis are: the existence of a protection area within a ray of 6m, presence of donkeys nearby, presence of garbage and excrements of animals, stagnant water pools, proximity of cesspools, proximity of garages and non asphalted roads.

The 7 criteria related to the 2nd axis are: quality of the canals system which supplies the TFs, high level of the basin, presence of holes in the basin, presence of top and 'margelle' of the basin, the canalization system of the National Water Company (SNDE) is underground, presence of pumps and presence of water-proof shutters around reservoirs.

The 11 criteria related to the 3rd axis are: the use of protection equipment by the operator, use of protection equipment by the distribution agent, manual drawing of water, transporting water with a pump, use of a high flexible tube with a tap at the outlet, point of hooking with tap in altitude, maintenance of the pump, regular disinfection of the basin, regular disinfection of the reservoir and water quality control in the basin and in the reservoir.

2.2.2 Physico-Chemical and bacteriological control of supplied water

The physico-chemical and bacteriologic analyses (tests) were carried out on the two extreme TF (TF1 and TF2) selected according to the method (visual quotation) previously described by Ould Ahmedou B.[5]. All measurements were carried out at the Laboratory of Molecular Chemistry and Environment of the Faculty of Sciences and Techniques of Nouakchott.

Samples were taken from two selected terminal fountains of which the first appears to be in worst situation (TF1) while the second in a better status (TF2). A total number of 18 samples were taken for each TF (Bad TF, Good TF).

Selection of samples is made at various points of the water distribution channel, that is: the reservoir or basin of the terminal fountain, the barrel of water-selling carter (metallic, plastic), the barrel or flask of the household and the can of the household directly supplied from the TF.

Physico-chemical analyses/tests (pH, electrical conductivity, temperature, turbidity, salinity, NO_3^- , NO_2^- , Ca^{2+} , Mg^{2+} , Cl^- , K^+ , Na^+ and SO_4^{2-}) are accomplished by volumetry and UV-visible spectrophotometry according to usual AFNOR norms.

The bacteriological analyses concern total coliforms and Escherichia. Coli. These germs are recognized and quantified by the Colilert method. This method comprises two types of testing: the qualitative test Presence – Absence (P/A) and the quantitative test by Quanti Tray.

The protocol test (P/A) for identifying the germs is the following: 100 ml of sample is mixed with Colilert product in a sterile flask of Colilert-18. After an 18 hours incubation at $35^\circ\text{C} \pm 0.5^\circ\text{C}$ inside a boiler, the reading of P/A is carried out with a UV-lamp ($\lambda = 365 \text{ nm}$) put in a dark room. The references are given with the Colilert product. Distilled water is used to prepare reagents and growing environment.

The quantitative analysis/test by Quanti Tray is: 100 ml of sample is mixed with a Colilert ampoule in a sterile flask of Colilert-18. Then, this mixture is put in a Colilert- 18 envelope. After 18 hours incubation at $35^\circ\text{C} \pm 0.5^\circ\text{C}$, the yellow or yellow fluorescent are measured wells using the MPN table of Colilert product.

3. Results and discussion

Table 1 shows the results of the inquests concerning the perceived quality and the produced quality of fresh water distributed to the inhabitants. These results are formulated by percentage or in form of remarks. This table shows, on the one hand, concerning the criterion related to the typology of homes, that half of the inhabitants of the districts of El Mina and Sebkha have fragile or weak homes (in zinc or in garment), and on the other hand, that families in these areas are large (made of numerous members) and poor (revenue per month < 100 euros). These populations are aware enough of the importance of water quality and the negative effect and risks related to irresponsible but frequent behaviour of throwing out of their waste liquid just before their houses, in a well or in special pits near their homes. The rate of connection to the distribution network, the sewerage system and the rate of access to water are very low for both poor districts of El Mina and Sebkha. These medium rates of, 22%, 4% and 35% respectively for the above parameters, are due to households in the district of Teveragh-Zeina (rich area). The average of access to the network supply, to the sanitation system and the access to fresh water are all weak in the two poor districts of El Mina and Sebkha. Our survey has also shown that 85% of the households have a water consumption of less than 150 liters/day; that is 15 liters/day/ per person.

This consumed quantity per person for the inhabitants of El Mina and Sebkha is about ten times less than the average water consumption in Europe. This situation is explained, on the one hand, by the typology of homes and on the other hand by the very low accessibility to water (high price of m³ of water and the distant water distribution network of the national water company (SNDE).

Table 1. Results of surveys of households on water supply in Nouakchott

Criteria	Issues	Results of inquest
Classification of households (standard of living)	House made of zinc or garment	40 %
	Families having more than 3 persons by household	81 %
	Families having a monthly revenue less than 40 000 UM (100 €)	84 %
Level of sensitizing of households to quality of water and environment	Importance of quality of air	76 %
	Importance of quality of water	88 %
	Importance of the protection of ground water	64 %
Level of access to water and sanitation	Impact of sewage / waste water rejection	85 %
	Average of access to the distribution network	22 %
	Average of access to the system of sanitation	4 %
	Average of access to water	35 %
	Quality of water pressure (good)	7 %
	Households having a consumption < 150 liters/day	85 %
Level of the purchase price of 1 m ³ of water	Households spending more than 1000UM / m ³ of water	63 %
	Households who think that water is very expensive	95 %
Water pollution and diseases linked to drinking water and sanitation	Main causes of water pollution	dust, sand, wind, animals, garbage, garages, shops, wastes and cesspools
	Main causes of mortality/death in the districts	Cholera, malaria, diarrhea, fever, hepatitis, hypertension, cancer and traffic accidents
	Average of mortality and birth	High
Household's priorities	Most households wants as a priority	A better access to water (price, connection to the city water networks

In fact, these two factors (high price of 1m³ of water, remoteness from the water network) led to the fact that the inhabitants can neither purchase a sufficient quantity of drinking water nor provide storing equipments which can insure a good conservation of their drinking water. Although these inhabitants are much concerned about the quality of supplied water, we notice that the main causes of death among them are diseases linked to the distributed water, something that has already been shown by Haslay and al. [6]. As a result, it is important to carry out physico-chemical analyses at the level of terminal fountains and bacteriological analyses on all stages of the distribution channel in order to identify the starting point of the contamination, that is to show if the contamination occurs at the beginning (upstream) and is then worsened at the level of homes or if it happens only at the level of households' storing instruments. For a reliable physical-chemical and bacteriological analysis, it is important first to make a visual rating of the fountains in order to select the two extreme terminal fountains. The use of indicators given in Table 2 and 3 allowed us to classify the 30 studied terminal fountains. 13 terminal fountains are marked with lower than the average grades, while the rest 17 follow the same typology with grades varying from 25 to 36.

Table 2. Main axes of visual quotation of TF and SR

	Number of studied criteria	Number of grades (marks)
Area protection of the terminal fountain (nature of immediate/close environment of TF and SR)	7	14
Technical status of TF or SR (basin, reservoir and canal system)	7	14
Health security of TF and SR	11	22
Total	25	50

Table 3. Outcome of the investigation about the perceptible criteria of the technical status of the studied 30 TF and basins / reservoirs

Status of the terminal fountain (TF) or the storing reservoir (SR) of water	Numbers	Expressions in percentage
Number of permanent customers of terminal fountain	16 ≤ Number of customers ≤ 50 (water-selling carters)	
Distribution of TF per technical classification	Just a basin = 8	27 %
	Basin + a pump = 10	33 %
	Basin + pump + reservoir = 12	40 %
Status of water pressure of TF	Good = 7	23 %
	Medium = 12	40 %
	Bad and tank = 11	37 %
The TF having technical problems	7	23,00%
Presence of donkeys nearby, of garbage, animal excrements and stagnant water	26	81,00%
Proximity of cesspools, garages or roads	29	97,00%

We have thus chosen, for our analyses, the extreme Terminal Fountains N°2 and N° 29; TF N° 1 and N°30 are not representative of Nouakchott's TF because these two fountains are located at remote places of the district, and are often not used by water distributors.

As for the two selected TF, the best one (*robinet Saraghoule*) is situated in the district of Sebkha. As for the worst fountain (*robinet Kebbet Mendez*), named after the slaughter-house close to it in the district of El Mina, it is situated in an area of shantytowns (*Kebba*).

Results of our physico-chemical analyses/tests during the two campaigns of sample taking are conform to the quality norms/standards of the WHO (World Health Organization), as well as to results obtained by Ould Ahmed [7].

The above data and the results of the respective bacteriological analyses, are summarized in tables 4 and 5. These tables show that, for the two analysis campaigns in the two target districts and for the two TF, we get 12 results P/A and 26 results of numeration (Quanti Tray). Results of the analyzed samples in the first part of this campaign have led to the conclusion that ten out of the twelve analyzed samples are contaminated with total coliforms (CT) and *Escherichia Coli* (EC).

Bacteriological results of the second analysis (test) campaign are identical to those of the first and show a sizeable pollution by total coliforms and a relatively low contamination with *E.Coli*. Moreover, a systematic correlation between the contamination by CT and EC is identified, for all the analysed non-conform samples, during the two campaigns.

A strong correlation was found between the bacteriologic contamination of the two studied terminal fountains and different practices observed during the household's investigations (performed with the help of TF's operators). This correlation is detailed as follows:

1. The contamination of the water at the initial point on the site of the TF through the manipulation of equipment used for fetching and distribution of water (manual extraction, plastic tubes to bring up water are thrown on earth over a polluted ground – sometimes sucked by mouth, etc).
2. Lack of maintenance and disinfection of basins and of the storing reservoirs which lack of technical and health quality (basin placed on the ground, insufficient water-proof quality, etc.).
3. Level of healthiness of the immediate environment (in the surroundings of TF) (presence of animals, cesspools, markets, mechanical garages, fuel stores, garbage, etc). Transport with carts drawn by donkeys often inside metallic barrels (flasks) in bad status.
4. Finally the storing quality in households by using polluted flasks and being made under bad conditions.

In addition, the lack of maintenance and disinfection of different transporting or storing tools, often without any care for the preservation of water quality. Besides, it was noticed that the results of bacteriological tests carried out on samples taken at the beginning of the distribution channel from the TF2 are not contaminated, on the contrary to the TF1; this confirms the results of the evaluation investigations of the TF. Likewise, and for further confirmation of the previous result, all samples taken from plastic 20-liter cans supplied directly by their owners from the TF2 are not contaminated.

In addition, most of the metallic barrels or flasks used by water selling carters or by households and whose appearance was awful, contained much more bacteria (CT and EC) than other samples taken from the same channel of distribution. This shows a major risk related to the use of such barrels or flasks some of which are primarily used for storing chemical products or pesticides that might spread many microbiological or organic contaminations.

The model of plastic flasks distributed by the Mauritanian Human Rights High Commission and well maintained by water-selling carters contained a relatively less number of bacteria (CT and EC), in comparison with other samples taken from the same distribution channel; this proves that it is good to advise users to utilize this kind of flasks that can be made more practical by putting a tap in the bottom.

Table 4. Summary of data of water analyses in 2007

Campaigns	Samples analysed	Counting (Quanti-tray) (100 ml)	P/A
1 st day of campaign March 2007	12	00	12
2 nd day of campaign March 2007	12	12	00
2 nd Campaign April 2007	14	14	00
Totals	38	26	12

Table 5. Results of the first campaign of analysis of 2007

TF	Number of samples	pH	CV ms/cm	P/A	Fluorescence
TF N°1	N°01	8.17	680	P	Positive
	N°02	8.08	611	P	Positive
	N°03	8.01	679	P	Positive
	N°04	8.06	684	P	Positive
	N°05	8.00	693	P	Positive
	N°06	7.21	687	P	Positive
TF N°2	N°07	7.97	675	A	négative
	N°08	7.93	681	P	Positive
	N°09	7.98	678	P	Positive
	N°10	8.01	681	P	Positive
	N°11	8.05	683	P	Positive
	N°12	7.99	674	A	négative

4. Conclusions

The global situation of the system of water distribution in Nouakchott is difficult on both quantitative and qualitative levels. An increasing lack of balance between the offer and the demand was noticed. In reality, the annual water production has known no significant improvement since 2000. In 2005, the production was less than 50.000 m³/day (of which 32.000 m³ are billed/invoiced), while the population of the city was about 560.000 inhabitants, and is estimated to have reached 750.000 inhabitants in the year 2005 (that is a growth of about 1/3 of the initial figure within a 5-year period). It is worth mentioning that this figure in the water production has reached around 65.000 m³/day at the beginning of 2010.

The water distribution system remains unreliable. It still relies on a fragile network (terminal fountains, donkey-drawn carts, etc). According to the present investigation/survey the non connected population in the two studied districts accounts to the 89% of households. As for the cost generated by this unbalanced distribution of fresh water, the results of the Mauritanian Development Agency (ADU) [8] and those of the aforementioned investigation show that the minority of Nouakchott's inhabitants connected to water networks pay a many times less price for water than other unconnected inhabitants with the majority living in precarious areas of the city.

On the quantitative level, the results of the physicochemical analyses show that the quality of water in the distribution network and in the terminal fountains conforms to WHO norms/standards. However, on the bacterial level, the TF are contaminated.

In order to improve the quality of management of the drinking water distribution system in the city of Nouakchott, the following solutions are suggested:

- The network supply should be developed on both medium and long terms, by accelerating the start of "Aftout Essahili" project, in order to avoid a risky excessive pumping at the Idini's water field, and also by giving a particular care to the processing of water coming from the river. In fact, the new expected water supply provided by this project aims at meeting the needs of a swiftly increasing population, considerably improving the unitary equipments and ensuring drinking water supplies of the capital during the next thirty years;
- Regular disinfection should be carried out for all TFs (source of supply for the majority of inhabitants in popular districts);
- Health control must be improved by establishing laboratories for analysis/testing and control in city halls.

In addition, and in order to guarantee a better hygiene control of such water sources, the following measures are suggested: taps must be generalized to all terminal fountains, the accumulation basins should be covered and disinfected daily. Moreover, the monitoring is sensible thus enabling to inform the population in real time of any possible pollution at such water points.

In conclusion, an urgent improvement of individual means of sanitation within the precarious districts of Nouakchott is necessary. The generalization of the sanitation network must be considered in order to avoid the negative influence of cesspools and waste liquid on the distributed drinking water, by rehabilitating the current cleansing station and by using less expensive means such as the lagoon system. A substantial improvement of household garbage collection system in the city must be made as soon as possible, the creation of a network for evacuating rain waters, particularly in the urban areas connected to sanitation networks and in high risk districts, must be envisaged in order to limit the spreading of some epidemics related to water stagnation especially, cholera and malaria.

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